Evaluating Corporate Capability by Applying Fuzzy Theory (PART Ⅱ)

— Yardsticks and Algorithms —

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I. Corporate Capability Evaluation of Management Resources and a Yardstick for Measuring Companies' Individual Characteristics

A) Funds

Here we will discuss the evaluation of one aspect of management resources, money, in other words funds. Funds are generally defined along the following lines :

'Capital within a company circulates, starting as cash, to inventory assets, to fixed assets, to trade receivables (which are close to being cash), and back to cash. When, during this circulation process, capital is in the form of cash or a cash equivalent, it is referred to as funds.[1]'

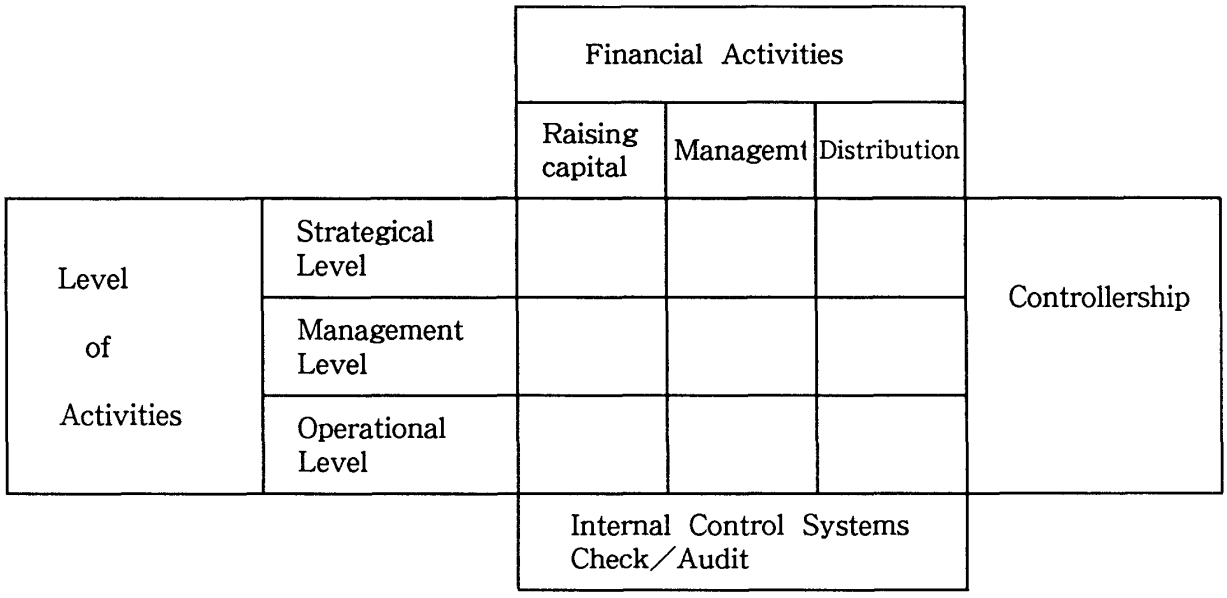
For accounting purposes, assets are divided into current assets and fixed assets. Funds correspond to those current assets which are also liquid assets. The proportion of assets which are liquid varies from industry to industry, and is of course affected by business conditions, but it constitutes quite a large percentage of overall assets. Management of liquid assets is an extremely important task for companies. Assets which are now funds may very quickly be converted to fixed assets or to inventory, for example. In other words, one of the characteristics of funds is that they seldom remain in the same form long periods .

Because they are frequently coming in and going out and because they are in such an accessible form , great care must be taken to see that there is no fraud or error in the managing of them. Also, like other corporate resources, they must be used efficiently. Hence an internal control system must be built in to the financial activities (raising, use, distribution of funds) of the company, to prevent fraud and errors. This will only work effectively if both elements of the internal control system, the checking system and the internal audit,

work in conjunction with each other. Also the efficient use of funds requires planning and effective management by top, middle, and lower management, in other words at strategical, day－to－day management, and operational level. It is the task of the controllers to give advice if any discrepancies arise at any level and whether management funds is appropriate for the company as a whole.

The amount of funds a company has does not necessarily express its capability. We believe, therefore, that an evaluation of corporate capability should focus not on the funds themselves, but on the appropriateness of the systems used to manage them. In Figure 9 below, we set out a conceptual framework for evaluation of those systems.

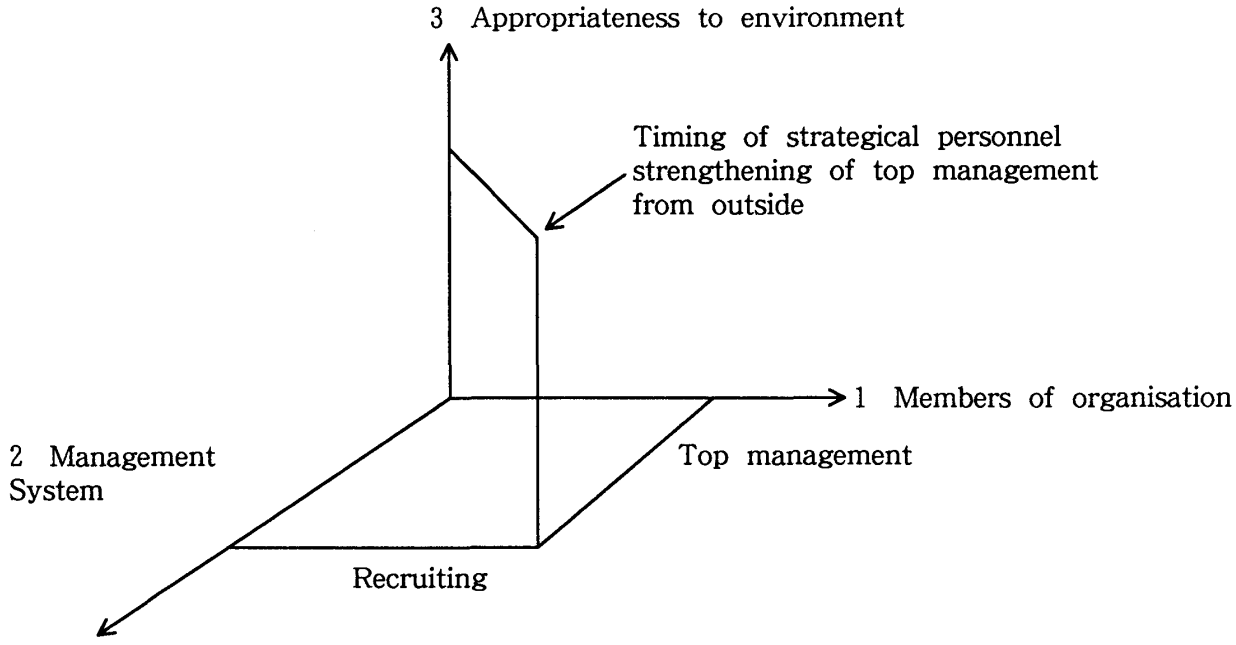
Figure 9 Concept Diagram for Evaluation of Funds Management Systems



B) Human Resources

It is possible to consider human resources evaluation factors in terms of the three axes shown in Figure 10 below.

Figure 10 Concept Diagram for Human Resources



The three axes in the above diagram give us the following areas for analysis :

1. The members of the organisation

   By the members of the organisation we mean all the members, from top management to employees at the lowest level, in other words all the human resources of the company.

2. Management systems

   There are three categories of management systems for human resources, those dealing with ability, those dealing with tasks (jobs), and those dealing with cost.

3. Appropriateness to the environment

The standpoint for looking at the appropriateness of management systems to the environment is at the intersection of the the axis for members of the organisation and the axis for management systems.

Within this axial framework, strengthening of top management can be represented as shown in the diagram.

1. The members of the organisation

a) Categorisation of the members of the organisation

The members who make up the organisation can be categorised as follows :

(i) External groups/individuals which should be included

In deciding whether to include (in an evaluation) individuals/groups who are not actually members of the organisation (shareholders, government – related organisations, local community members, consumer groups) the question we must answer is whether or not they affect corporate capability. For example SOKAIYA (criminal elements who become shareholders in order to force companies to pay them not to disrupt shareholders' meetings) could be said to have a minus effect on corporate capability.

Thus groups/individuals outside the company may have to be brought into an evaluation of human resources. We will not, however, be discussing this question any further in this paper.

b) Categorisation according to level within company

This is where personnel are categorised according to their decision – making level, into top management, middle management, lower management, and ordinary employees (or into top/general/middle

/lower decision－making levels).

Alternatively they could be categorised according to their rank (position title), into Presidents, Directors, General Managers, Section Managers, Team Leaders.

Categorisation according to level within the company is a way of dividing the organisation horizontally to look at the composition of its human resources.

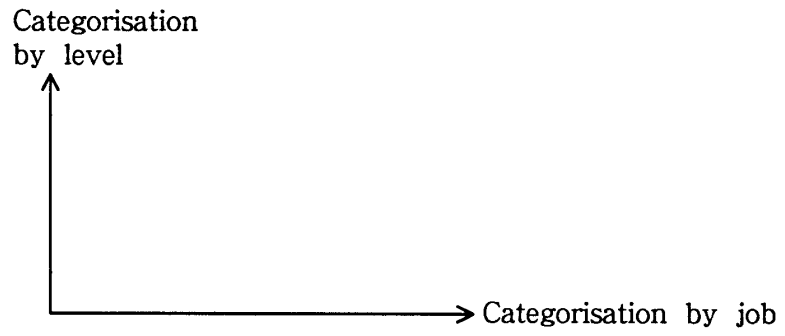
c) Categorisation by job group

If an organisation is seen simply in terms of the combined objectives of its work and its personnel, we can categorise the latter according to the nature of their work, Another way to categorise personnel is according to the terms used for job analysis,(job type, job group, job duties)[2].

Another way is to divide the organisation vertically (as in an organisation chart) and categorise according to organisational units (General Affairs, Finance, Sales etc.). Another way of describing these units is to call them business functionareas.[3]

b) An example of categorisation of members of the organisation

We give an example below of how the categorisation criteria described above might be applied, that is to say for the two axes (categorisation by level within company and categorisation by job) shown below.



(i) Categorisation by level within company

Top management

According to Ryuei Shimizu, 'Top management is the top stratum within a company. They consider how the long－term position of the company can be maintained／improved, make decisions on strategy designed to achieve this, and supervise／adjust／control the staff beneath them, based upon the decisions they have made'[4]

The people who represent top management usually have titles such as President, Director, General Manager, or Managing Director, We will categorise them as follows :

- Company Presidents
- Executive council
- Board Directors

- The company president is the person who represents the company, the ultimate decision－maker with overall responsivility for the highest executive function of.

- The executive council carries out the functions a board of directors would in a large company. It is the main organ of top management in present－day companies, and its function is to make correct decisions quickly. When we evaluate the executive council, the way it functions as a whole is as important as the qualities of the individual members[5].

- Directors, as well as being on the board of directors, are entrusted by the board to carry out the business of the company, and are obliged to report to the board on the progress of that business. Their individual qualities would be evaluated.

Middle management

Middle management are the people usually known as managers (heads) of departments or sections in most companies. As heads of

such organisations they are entrusted with the day－to－day running of the business. In the same stratum is another type of employee, the specialist in a particular field. Specialists constitute imortant middle management－level human assets.

Ordinary employees

The stratum below middle management is usually divided into lower management and ordinary employees, but here we treat them as one category. These days ordinary employees are normally graded according to some kind of qualifications system. Evaluation of the qualities of the employees might be carried out for each grade.

(ii) Categorisation by job type

Vertical categorisation according to the nature of the duties is suitable, practical approach for use in the evaluation of human resources. The range of duties will vary from industry to industry, but below we present a typical set of categories

- Clerical duties

  It is also possible to subdivide them by job group (General Affairs, Personnel, Finance, Sales, Production) On the other hand it may be necessary in some cases to, for example, divide clerical staff involved in planning into General Affairs planning staff, Personnel planning staff etc.

- Sales duties

  This category would include staff involved in sales／sales promotion. They may have to be subdivided into domestic sales staff and overseas sales staff.

- Production duties

  This would include staff involved in production, production control, production technology, and in some cases in purchasing areas.

– Research and development (R.& D.) duties

This category could be divided into basic R. & D. and applied R. & D.

Figure 11 below shows categorisation by level and by job expressed in the form of a matrix. The circles in the squares denote categories which would be evaluated.

Figure 11 Members of Organisation – Matrix

President	○			
Executive Council	○			
Board Directors	○			
Middle Management	○	○	○	○
Ordinary Employees	○	○	○	○
Level / Job	CLERICAL	SALES	MANUFACT	R & D

2. Management Systems

The question of whether there are in fact personnel management systems for top management – company presidents, executive council members, directors – is open to debate. In this paper we will not not discuss this question, but will concentrate on systems for middle management and ordinary employees.

a) Categorisation of Management Systems

Here we present evaluation checkpoints for various types of human resources management systems.

(i) Systems for Securing and Appraising Human Resources

These are systems for managing recruitment and headcount, in

order to recruit the correct number of employees, with appropriate qualities. It could be said that answer you get when you subtract the accumulation/combination of skills a company has at present, from the accumulation combination known to be required (now /in the future), will constitute what a company needs to recruit.

1. Relationship between management strategy and management systems
   - Is there a plan for recruitment which is in line with management strategy ?
   - Is there, in the personnel plan, a strategic policy for future improvements to the accumulation/combination of skills ?
2. Personnel plans
   - Are the long/medium/short term personnel plans linked up with/appropriate in terms of other management systems (eg, recruitment plans, labour cost plans) ?
3. Recruitment
   - Is recruitment of core employees, from among new graduates/ school leavers being carried out appropriately ?
   - Is the labour force being appropriately supplemented by recruitment of employees who have worked for other companies, part - time staff, and contract staff ?
4. Personnel information systems
   - Are personnel information systems such as CDP (Career Development Programmes) functioning properly ?
   - Are efforts being maintained to improve the functioning of personnel information systems , and the training and development of managers ?
5. Appraisal systems
   - Are appraisal systems such as merit rating, performance

appraisal, management by objectives functioning appropriately?

- Are efforts being maintained to improve the fairness of appraisal and the degree of satisfaction with it, through, for example, management training?

6. Qualifications/Grading system

- Has the qualifications system been designed appropriately so that it accurately reflects ability to carry out work?
- Are systems for management of upgrading, training for each grade etc. functioning properly?

(ii) Staff Development Systems

By this we mean management systems for training and development to improve the capabilities of present employees. A company's training needs are equal to the difference between the current and desired capabilities of its staff, as expressed in the following equation.

Desired capability − Current Capability = Training Needs

By desired capability we mean the human qualities and skills that are needed now/will be needed in the future; a plan of the desired combination of skills and qualities must be designed. Management systems must be built up to provide the desired combination of skills and qualities for each grade and each job type.

By current capability we mean the existing human qualities and skills in a company. Qualifications/grading systems and personnel information systems for each grade and individual are controlled by management systems such as personnel information systems, C.D.P.

1. Job development

- Are employees allowed to expand the content of the jobs they have been given, or are there moves afoot to allow this practice.
- Have challenges been systemically built into the work by

systems such as JIKO SHINKOKU (a system whereby employees fill in reports about the content of ther own jobs, which includes their opinions, suggestions, and requests for training etc.), systematic observation of one's supervisor, management by objectives?

2. Job rotation, promotion
   - Is job rotation managed so that it takes into account the job development needs of the employees?
   - Is promotion always carried out in response to the needs of the organisation, with the approach being to select the right person for the right post?
3. Staff development
   - Is staff development systematically divided into long/middle/short term development, and on-the-job / off-the-job training?
   - Is on-the-job training managed in a systematic way?
   - Have ways of encouraging employee self-development (eg. through correspondence courses) been introduced?

(iii) Systems for Raising Morale

The factors which help raise morale are motivation of the members of the organisation to achieve organisational objectives, good human relations, cooperation between groups, and vitality within the company. Raising morale is normally understood simply in terms of motivating individuals. It could be said that the changes over the years in management theory, expressed in papers on scientific management, human relations theory, and behavioural science, have focused on developing theories of human resources management aimed at raising morale within organisations.

1. Improving motivation
   - Are any measures (such as management by objectives, small group management) being taken to improve employees' motivation?
2. Raising morale
   - Are measures being taken to raise morale by improving communication (via eg. company magazines, meetings)?
   - Are measures such as interviews between supervisors/subordinates, counselling in order to deal with psychological problems being carried out?
   - Are management systems in use which encourage employee participation (suggestion systems, prior consultation systems).

(iv) Systems for Maintaining Human Resources

The main reason that the members of the organisation work for the company is to satisfy their economic needs. These systems, however, are designed to satisfy their other needs within the company. They treat the people who work there not simply as members of the labour force, but as human beings, and are designed to enrich their lives as much as possible.

The importance of such systems (safety management, health management, working hours management, retirement age management, better use of older employees/ex-employees, and welfare schemes). will be increasingly stressed in the future.

a) Safety, health management
   - Are systems for ensuring the safety of the working environment and increasing employees safety-awareness being managed properly?
   - Are employee health management systems working properly?

b) Working hours management

- Is there a policy for reducing the number of hours worked, and are concrete measures to achieve this being carried out?
- Are futuristic elements being incorporated in working hours management (flexitime systems, work being done at home, refresher holidays)?

c) Measures for the middle-aged, older employees

- Are measures being carried out to make better use of middle-aged/older employees (SENMONSHOKUSEI - relieving specialists of management responsibilities, redesigning of their jobs, early removal of people from management posts-eg. section head at 49 yrs, or section heads who do not make department head in 5 years), in order to increase the vitality of the company?
- Are personnel management systems based on ability (as opposed to seniority) properly applied to middle-aged/older staff, in order to maintain the vitality of the company as a whole?

(v) Cost Management Systems for Human Resources

These are management systems for the costs entailed in activating human resouces, in other words labour costs. Payment itself must not be the sole objective of the system for paying labour costs. it must also function as a sub-system for stimulating the members of the organisation's desire for job development.

It is also essential to study how to include all the various labour cost systems (wages system, bonus system, retirement benefits system etc.) within an integrated labour costs system.

a) Wages system

- Is the wages structure designed so as to rationally/

scientifically reflect basic personnel policy?

- Is the wages level high enough to be competitive on the labour market, so that it does not represent a hindrance to recruitment?

b) Bonus system

- Do the bonuses paid reflect the performance of the company?
- Are performance/results represented in the criteria for apportionment of bonuses?

c) Overall managemant of labour costs

- Is the company's ability to pay labour costs checked, and a plan formulated with appropriate limits on what labour costs (including wage levels, bonuses, retirement benefits etc.) are to be paid?
- Do the personnel department staff make sufficient efforts to make the top/middle management aware of the importance of total labour costs control?

3. Appropriateness to the Environment

An example of this third axis of Fig. 10 above (using the matrix formed by the two axes −1. members of the organisation and 2. management systems) might concern the staff development system for ordinary sales staff where a company's competitors are placing considerable emphasis on internationalisation in their staff development programmes. If this was the case, evaluation of appropriateness to the environment (which of course includes competitors) would have to include the training programme for sales staff in respect of internationalisation.

Appropriateness to the environment must always be taken into consideration when individual management sub−systems are evaluated.

C) Information, Technology, and Equipment

Since the 1970s Japan has progressed from being a data-based society to become a high-tech data-based society. In this environment, companies must regard their information resources as an extremely valuable addition to their other assets capital, energy, and meterials), and the important question then is how effectively they can use the data they possess. These changes are of course affecting companies' ablity to compete, and resulting in new company groupings/organisation, changing industrial structures, as new types of data products based on networking come onto the market. Hence a new revolutionary task for present-day companies is to maintain a structure which is capable of rapidly responding to the changing data situation.

Hence here we present an approach to corporate capability evaluation which looks at information, technology and data processing equipment .

Figure 12 Evaluation Factors and Progress Levels for Hardware

Type of Hardware	Stages of Progress (Level)			
	I	II	III	IV
Wordprocessors	0	0	0	0
Facsimiles	0	0	0	0
Personal Computers	0	0	0	0
Office Computers	0	0	0	0
Coupled Terminals		0	0	0
Multi - function Workstations		0	0	0
Local Area Networks (LAN)			0	0
Wide Area Networks (WAN)				0
Value Added Networks (VAN)				0
International VAN				0

Note :

The types of hardware shown in this chart constitute only an example of what might be used. They (and the evaluation) would vary according to the type of business a company is in.

Evaluation factors for information technology/data processing are divided into factors concerning hardware and factors concerning software.

A great many evaluation factors could be considered for hardware, but here we will use the ones shown in Figure 12, as criteria for corporate capability evaluation.[6]

The objective at Level (stage of progress) I is to free the members of the organisation from simple, repetitive tasks, so that they can concentrate on ones which require human skills. In other words OA (office automation) at this level consists only of stand-alone hardware -office computers, personal computers, wordprocessors, and facsimiles. The hardware is being used to automate manual operations (data/text processing on a relatively small scale) and save labour.

Level II is where stand-alone computers etc, are connected to each other, in order to meet communication needs.[6] Coupled terminals and workstations are used to achieve standardisation throughout the company.

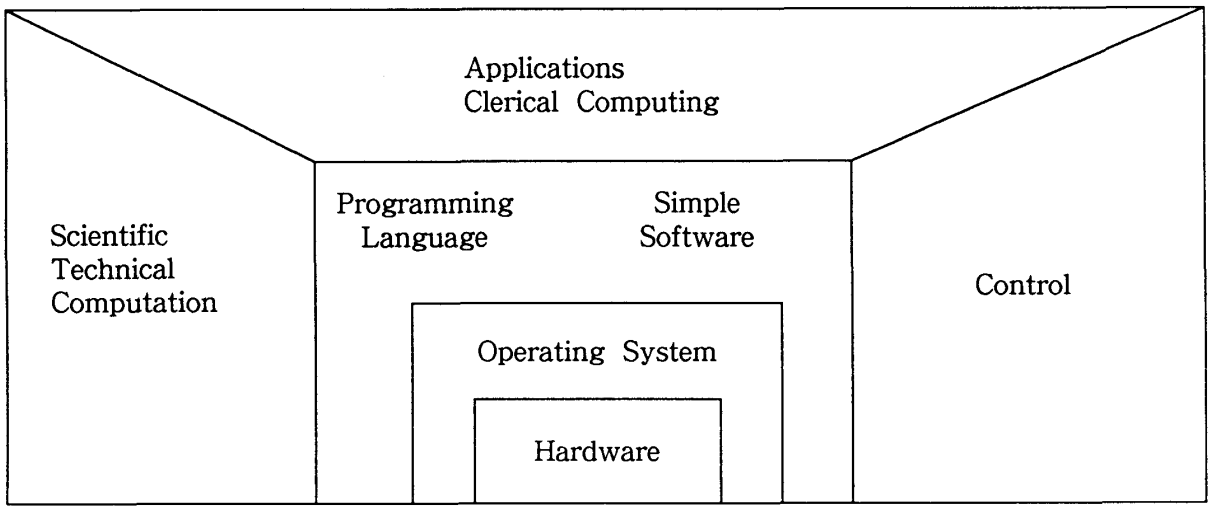
At level III all the computers and OA equipment in the offices are on a Local area network (LAN), via which communication can take place freely between the various machines. This can help improve the efficiency of the whole organisation, because all the various departments are now physically connected.

At level IV the LAN themselves are connected via digital networks and the whole of the company is connected with a whole range of other networks throughout society via WAN and VAN.[6] This facilitates

data exchange, not only within the company, but also with other companies and banks, and can greatly contribute to the company's strategical armoury.

In order to select evaluation factors concerning software we will look at the office software shown in Figure 13.[7]

Figure 13 Hardware and Software



There are all kinds of software, ranging from basic software such as OS (Operating Systems), to applications software. One type of applications software which is directly concerned with company management is known as DSS (Decision Support System). Figure 14 below shows a DSS model devised by Morton.[8] We have used this model in this paper to define one evaluation factor.

Figure 14 Information Systems : A Framework

	Operational Control	Management Control	Stategic Planning
Structured	Accounts Receiveble	Budget Analysis – Engineered Costs	Tanker Fleet Mix
	Order Entry	Short – Term Forecasting	Warehouse and Factory Location
	Inventory Control		
Semi – Structured	Production Scheduling	Variance Analysis – Overall Budget	Mergers and Acquisitions
	Cash Management	Budget Preparation	New Product Planning
Unstructured	PER/COST Systems	Sales and Production	R & D Planning

The extent to which decisions are structured is represented by the vertical axis in Figure 14, with the range of organisational functions represented by the horizontal axis. For example, structured, routine operations such as inventory control or personnel management systems call for decision support systems where the methods of analysis, planning, and control are tightly programmed. DSS for unstructured, strategic planning functions cannot be programmed to anything like the same extent.

Looking at the content of Figure 14 from an information technology and equipment standpoint we can say that the systems developed for

structured, routine operations are the least advanced. Conversely, the most advanced information systems need to be developed for decisions which are unstructured and strategical.

Figure 16 shows a combined evaluation of hardware and software. The shaded section gives an example in which the function of the software at a company which has been evaluated is at the management control level and unstructured decisions are involved. while the hardware has reached the stage where the various computers and other office machines are on a local area network, and communication between them can be effected freely via this LAN.

Figure 15 An Example of Corporate Evaluation Capability Structure viewed from an Information Technology and Equipment Standpoint

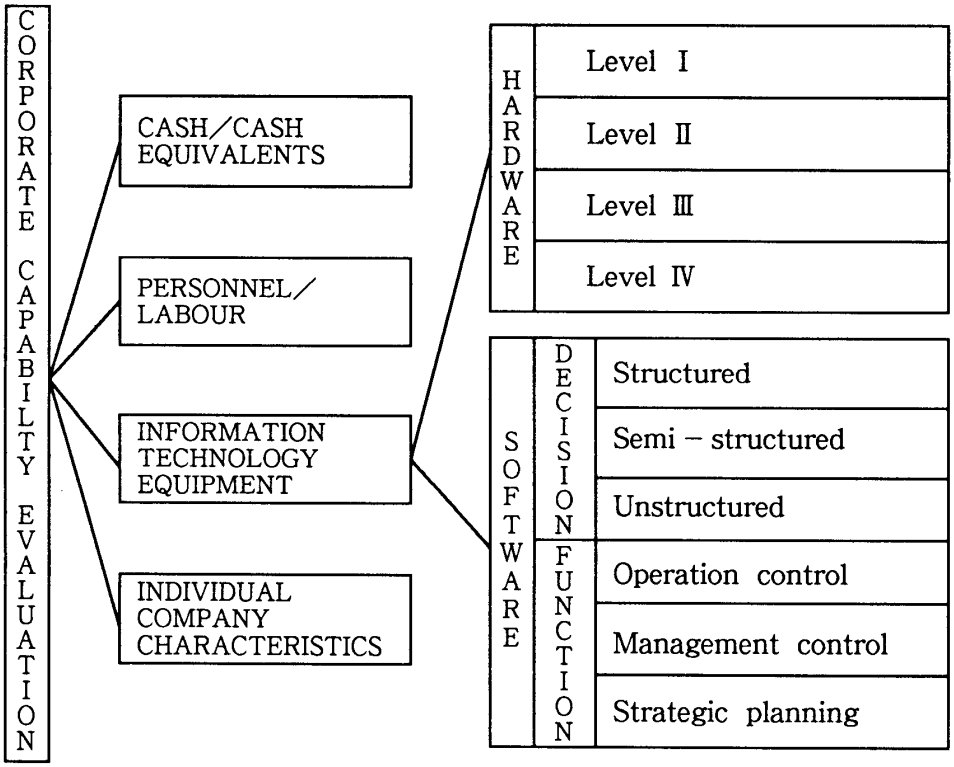
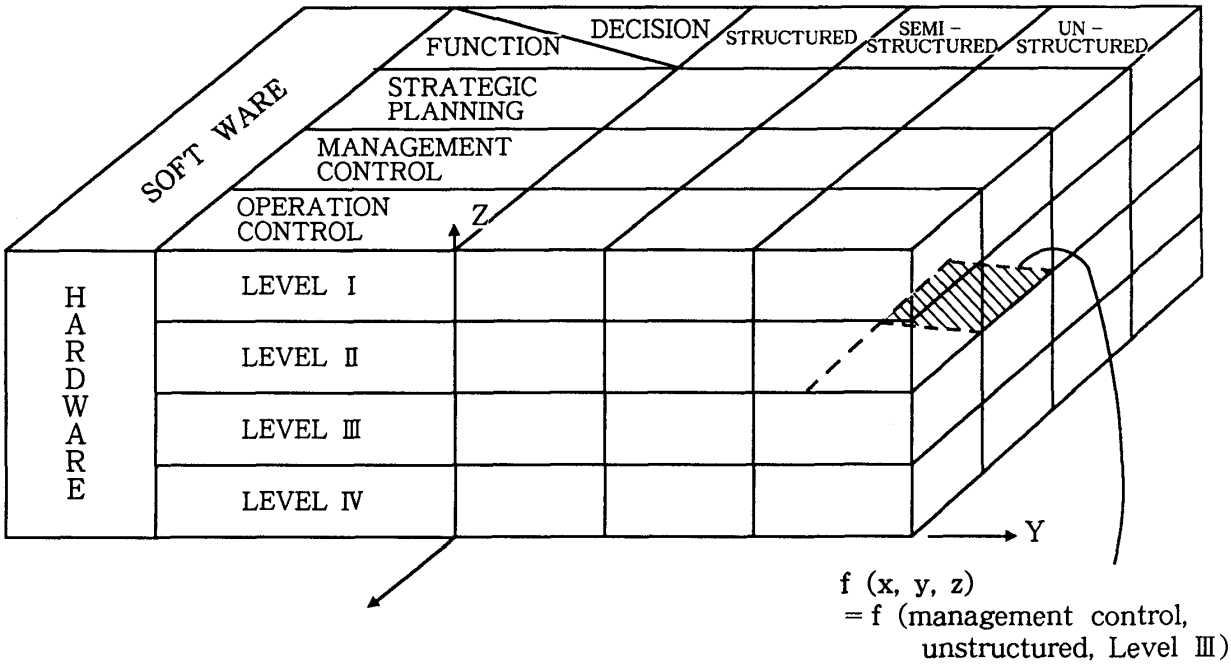


Figure 16 An Example of Overall Evaluation of Hardware and Software



In this example, corporate capability evaluation from the information technology equipment standpoint, G, can be defined as follows :

$$G = g\ (x,\ y,\ z),\ x \in X,\ y \in Y,\ z \in Z$$
$$g : X\ x\ Y\ x\ Z \rightarrow [0,\ 1] \qquad (1)$$

Here X represents the aggregate of the operations (decisions) that software systems are applied to, Y represents the aggregate of the functions involved, and Z represents the stage of progress as far as hardware is concerned. The corporate capability score can be determined using the function g, but its value will vary according to the objectives of the evaluation ; the evaluators use their knowledge and experience, based on a variety of surveys they have carried out, in determining it.

The approach described above is not always the ideal approach. We may also want to include a variety of evaluation factors concerned with interfaces and personnel－centred systems[9]. Hence we may ask questions such as "How much education on data handling is taking place within the company?" or "How far, and in what ways, are personnel involved in the setting up and utilisation of hardware?" or "To what degree has human and geographical diversity been taken into account?"

D) A Yardstick for Measuring Companies' Individual Characteristics Evaluating

Corporate capability only from the point of view of management resources is not enough.

In order to achieve an overall evaluation which is both appropriate and objective we need to include evaluation factors to cover unique aspect of individual companies. It is, for example, essential to evaluate the company culture which has grown out of the unique history of a company since it was founded.

Even though an evaluation factor may not conform to theory／logic, if that factor is essential in order to portray the state of a company, it must be included in the evaluation, because its inclusion will bring the results closer to the truth.

Ⅱ. An Algorithm for Evaluating Corporate Capability

We present the following algorithm, which uses fuzzy theory, for corporate capability evaluation.

Step 1 Determine the evaluation factors for each aspect－(Va) Cash and cash equivalents, (Vb) Personnel, (Vc) Data, technology, and equipment, (Vd) Individual characteristics of company.

Step 2 Produce the matrices Fa, Fb, Fc, Fd for Va, Vb, Vc, Vd as shown below.

$$F_k = [f_{ij}^k],\ i,j = 1,2,\cdots k_m \qquad k = V_a,\ V_b,\ V_c,\ V_d \qquad (2)$$

, where $0 \leqq [f_{ij}^k] \leqq 1$ and k_m represents the number of evaluation factors for k.

Step 3 Apply the system structuring method to F_K as calculated in step 2.

Construct corporate capability evaluation system structure, H_i, (i = V_a, V_b, V_c, V_d) for V_1 (i = a, b, c ,d), Then determine whether or not these system structures can in fact be used for H_i. If they cannot, change the parameters and reconstruct the corporate system structure using FSM (Fuzzy Structural Modelling). If, after changing the structural parameters, a system structure can still not be used, go back to step 1 ; once more determine the evaluation factors, then proceed to step 2. By repeating steps 1 to 3 we can obtain the corporate capability evaluation system structures, H_i (i = Va, Vb, Vc, Vd) for aspect V_1 (i = a, b, c, d).

Step 4 Calculate the weightings for the evaluation factors which make up V_1 (for H_1 obtained in step 3). Express the weightings, as follows, in terms of their degree of importance.

$$W_i^* = (e_{i1}, e_{i2}, \cdots, e_{iki}),\ i = V_a,\ V_b,\ V_c,\ V_d \qquad (3)$$

Here k_1, (i = V_a, V_b, V_c, V_d), represents the number of evaluation factors for aspects i.

Step 5 Produce a fuzzy subordination matrix, as shown below, by comparing all the pairs formed by Va, Vb, Vc, Vd. Calculate the weightings, using either the eigen values and eigen vectors, or ratios.

$$F = \begin{array}{c} \\ V_a \\ V_b \\ V_c \\ V_d \end{array} \begin{array}{c} \begin{array}{cccc} V_a & V_b & V_c & V_d \end{array} \\ \begin{bmatrix} 0 & q_{ab} & q_{ac} & q_{ad} \\ q_{ba} & 0 & q_{bc} & q_{bd} \\ q_{ca} & q_{cb} & 0 & q_{cd} \\ q_{da} & q_{db} & q_{dc} & 0 \end{bmatrix} \end{array}, \quad 0 \leqq q_{ij} \leqq 1 \qquad (4)$$

Here g_{ij} (i, j = a, b, c, d), indicates that corporate capability evaluation aspects i are degrees more important than j for the evaluation of a company in the sector (industry).

Step 6 Express the weightings calculated in step 5 in terms of the degree of importance for V_i, (i = a, b, c, d) for the sector (s) concerned.

$$W_v = (W_a, W_b, W_c, W_d) \qquad (5)$$
$$0 \leqq W_i \leqq 1, \; i = V_a, V_b, V_c, V_d$$

Step 7 By finding the product of the degree of importance for the aspects calculated in steps 6 and 4, we can calculate the relative degrees of importance of the evaluation factors for the various aspects.

$$W_i = W_i \cdot W_i^*, \qquad i = V_a, V_b, V_c, V_d \qquad (6)$$

Step 8 Carry out corporate capability evaluation for aspects V_i, (i = a, b, c, d).

This could be done either (1) by a comparison with the competitor companies in the same sector, or (2) by a comparison with the ideal image for the company being evaluated. We propose here a method of evaluation which will allow either.

Evaluation Method

Carry out evaluation based on comparisons of pairs of companies from the standpoint of evaluation factor S_{vi}^k for V_1, and produce the following corporate capability evaluation matrix :

$$G_{vi}^k = \begin{array}{c|cccc} S_{vi}^k & h_1 & h_2 & \cdots & h_n \\ \hline h_1 & g_{11}^{ik} & g_{12}^{ik} & \cdots & g_{1n}^{ik} \\ h_2 & g_{21}^{ik} & g_{22}^{ik} & \cdots & g_{2n}^{ik} \\ \vdots & \vdots & \vdots & \vdots & \\ h_n & g_{n1}^{ik} & g_{n2}^{ik} & \cdots & g_{nn}^{ik} \end{array} \qquad 0 \leqq g_{1m}^{ik} \leqq 1, \quad 1,\ m = 1,2 \cdots,\ n \tag{7}$$

Here G_{vi}^k , (i = a, b, c, d), is a matrix for comparing companies h_i, (i = 1, 2, ⋯ , n) from the aspect of the 'k'th evaluation factor S_{vi}^k , of V_i.

g_{lm}^{ik}, $(0 \leqq g_{lm}^{ik} \leqq 1)$ is a membership function indicating that, from the standpoint of evaluation factor S_{vi}^k, h_l is preferred to h_m.

By calculating either the eigen value and the eigen vector, or the ratio for equation (7), we can calculate corporate capability scores from the evaluation factor S_{vi}^k .

The scores we get are expressed as follows :

$$E_i^k = (E_{i1}^k,\ E_{i2}^k,\ \cdots,\ E_{in}^k),\ k = 1,2,\ \cdots,\ im \tag{8}$$

where i = V_a, V_b, V_c, V_d and im is the number of i evaluation factors. Here E_{in}^k expresses the score for company 'n', from the standpoint of

the 'k'th evaluation factor S_i^k , for corporate capability evaluation aspects i. Then $\sum_{j=1}^{n} E_{ij}^k = 1,\ 0 \leqq E_{ij}^k \leqq 1,\ (j = 1,2, \cdots, n)$.
When equation (8) is expressed for each evaluation factor we get :

$$\left.\begin{aligned} E_i^1 &= (E_{i1}^1,\ E_{i2}^1,\ \cdots,\ E_{in}^1) \\ E_i^2 &= (E_{i1}^2,\ E_{i2}^2,\ \cdots,\ E_{in}^2) \\ &\vdots \\ E_i^{im} &= (E_{i1}^{im},\ E_{i2}^{im},\ \cdots,\ E_{in}^{im}) \end{aligned}\right\} \qquad (9)$$

The score from aspects V_i for a company can be calculated in equation (10), using the multiple attribute criteria evaluation method :

$$E_i = W_i \cdot \begin{bmatrix} E_i^1 \\ E_i^2 \\ \vdots \\ E_i^{im} \end{bmatrix} \triangleq (P_i^1,\ P_i^2,\ \cdots,\ P_i^n),\quad i = V_a,\ V_b,\ V_c,\ V_d \qquad (10)$$

The overall score Rj, from all the aspects, V_i, (i = a, b, c, d), can be calculated using equation (11) :

$$R_j = \sum_{i=va}^{vd} P_i^j,\ j = 1,2, \cdots, n \qquad (11)$$

Calculation of the score using fuzzy integral is done as follows :

Algorithm using fuzzy integral

Step 1 Sort the scores E_{ij}^k, $(k = 1,2, \cdots, im)$ viewed from evaluation factor S_i for V_i (i = a, b, c, d) in descending order.

Step 2 Arrange W_i corresponding to E_{ij}^k, sorted in step1, then find the fuzzy distribution function for W_i^k using the following equation :

$$H\ (S_i^j) = W_i^j + H\ (S^{j-1}_i) + \lambda\ W_i^j H\ (S^{j-1}_i)$$
$$H\ (S_i^j) = W_i^1, \qquad i = V_a,\ V_b,\ V_c,\ V_d$$

Step 3 Calculate the score P_i^j, $(j = 1, 2, \cdots, n)$ using the following equation :

$$P_i^j = \bigvee_{k=1}^{im} [E_{ij}^k \wedge H\ (S_i^k], \quad i = V_a,\ V_b,\ V_c,\ V_d$$

Step 4 The overall score Rj, for all the aspects, V_i, (i = a, b, c, d), can be calculated using the following equation :

$$R_j = \sum_{i=va}^{vd} P_i^j$$

Using the above algorithm, corporate capability scores can be calculated for funds, human resources, data/technology/equipment, and for a company's individual characteristics. From these we can calculate the overall score.

Ⅲ In Conclusion

In these paper we have presented the following procedure for corporate capability evaluation. First we express corporate capability evaluation factors as fuzzy sets, and give fuzzy item correlations for these factors. Then, by using a system structure construction method based on fuzzy theory, we produce corporate capability evaluation factor structures, and weightings for the evaluation factors.

We then use the resulting corporate capability evaluation system structures to produce matrices. Finally, using multiple attribute criteria and fuzzy integrals, we calculate the overall score for a company.

As we have said, with this method it is possible to produce an overall corporate capability evaluation from the four aspects of corporate capability (funds, human resources, information/technology /equipment, and a company's individual characteristics), and it is a method which can be adapted to the situation in order to meet the objectives of the evaluation.

We have designed the above method based on questionnaires sent to/interviews with management level staff in companies and academics. We cannot yet say whether it is really possible to use, from the point of views of fairness and validity ; this can only be ascertained by the practical work with it which we will undertake in the future.

Sources of Reference

1. K. Someya, Shikin, in *Kaikeigaku Jiten (Dictionary of Accounting)*, ed. Kobe University Kaikeigaku Kenkyushitsu, pub. Dobunkan, 1984, p.571.
2. Hanaoka and Mukai, *Shokuno Kaihatsu Jinji Kanri*, pub. Hakuto Shobo, 1973, pp. 141－142.
3. Mukai and Hanaoka, *Senryakuteki Kigyo Kodo*, pub. Hakuto Shobo, 1977, pp.128－131.
4. R.Shimizu, *Kigyo Seicho Ron*, pub. Chuo Keizaisha.
5. Re Executive Councils, see Hanaoka and Maruyama, *Keieigaku Soron*, pub. Hakuto Shobo, 1990, pp. 204－208.
6. Takamatsu, Araki, Hayashida, Nagabayashi, and Amagasa, OA to Ishi Kettei Shien Shisutemu (DSS) － OA Gainen no Saikento (Daito Bunka University Institute of Business Research, Research Paper No.8).
7. Amagasa, *Joho Shori no Kiso*, pub. Asakura Shoten, 1991, p.57.
8. Suzuki, Ishi Kettei Shien Shisutemu o Jissai ni Tekiyosuru ni atatte no Kadai ni Kansuru Ichi Kosatsu, in *Office Automation*, Vol. 7 No.2, 1986, pp. 24－30.
9. Nuki, Gijitsu to Bunka － Ningen Chushinsei no Shiten kara (paper read at *ICS Symposium 1992*).